Regional HOT Lanes Network Feasibility Study

APPENDIX D

CORRIDOR ANALYSIS:
I-680 FROM MARTINEZ TO LIVORNA

Prepared for:

Metropolitan Transportation Commission

and

California Department of Transportation

Prepared by:

Parsons Brinckerhoff

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Introduction

This memorandum applies a project development approach and set of corresponding design principles that were developed in Phase 3 Tasks 22.1 and 22.2 to the specific portion of I-680 from the Benicia Martinez Bridge to Livorna Road. Similar memoranda are being prepared for four other corridor segments in the proposed MTC HOT lane network. These memoranda are intended both to advance the plans for HOT lane development in the corridors under study and to provide a basis for drawing conclusions about the likely impacts, costs and design issues required to convert or develop HOT lanes in other network corridors not under detailed study.

At the direction of MTC and the Project Steering Committee, this analysis covered two approaches to developing HOT lanes in the corridor, the "Basic Approach"[1] and the "Revised Full Featured Approach"[2]. The primary difference between the two is that in constrained situations the Basic Approach allows for sub-standard inside shoulders and a reduction of lane widths from the 12-foot standard to 11 feet in order to make the added lane fit within the available right-of-way, while the Revised Full Featured Approach would maintain Caltrans design standards. Under exceptionally constrained conditions where freeway widening is infeasible due to cost or environmental reasons then the outside shoulder may also fall below Caltrans' 10-foot standard width for short distances.

This memorandum begins with a description of existing conditions in the corridor, followed by sections describing the proposed typical HOT lane sections and access and egress points, and closes with a section describing the study team's findings regarding development of HOT lanes in this corridor.

[1] This is derived from the "Rapid Delivery Approach" in Phase 2b of this study

[2] This is derived from the approach used in Phase 2 of this study, which assumed full Caltrans design standards

Existing Description of the Corridor

This corridor segment is 13.5 miles long, running from the Benicia Martinez Bridge to Livorna Road. This section of I-680 is located in the medium-density urban areas of Martinez, Concord, Pleasant Hill, and Walnut Creek (see Figure 1). There are three freeway-to-freeway interchanges (SR-4, SR-242, and SR-24) and fourteen other interchanges[3].

The section of I-680 under study consists of three portions that can be described from north-to-south as:

- From the Benicia Martinez Bridge to the junction of SR-242, I-680 generally has three general purpose lanes per direction. In 2005, a contiguous HOV lane was added in each direction from the Marina Vista Interchange to the North Main Street Interchange on the southbound side and to SR-242 on the northbound side. There are several pinch points in this section where both the inside and outside shoulders are reduced to 2 feet (see Figures 2 and 3).
- From the SR-242 interchange to the SR-24 interchange I-680 widens to six or seven lanes per direction with complex weaves and high volumes of entering and exiting traffic, including a heavy volume of northbound traffic entering from the left-side connector ramp from SR-24. Near the SR-24 interchange the configuration is further complicated by five overcrossings and two under-crossings (see Figure 4). This creates a very complex environment for drivers (see Figure 5). This section of I-680 is constrained by land development very close to the freeway (see Figure 6).
- South of SR-24, I-680 has five general purpose lanes in each direction tapering down to four near Livorna Road. The existing HOV lanes have their north endpoints at Livorna Road.

[3] From north to south, these are: Marina Vista Avenue, Arthur Road, Pacheco Boulevard, Concord Avenue, Willow Pass Road, Gregory Lane, Monument Boulevard, Contra Costa Boulevard, Oak Road, Treat Boulevard, N. Main Street, Olympic Boulevard, S. Main Street, and Rudgear Road.

This portion of I-680 carries heavy volumes of commuter traffic during peak hours. Daily traffic volumes vary from a low of 150,000 ADT near the Benicia Martinez Bridge to a high of 266,000 ADT between SR-242 and SR-24.

Other Projects and Studies in Vicinity

There are several projects and studies relevant to I-680 in this area:

- An environmental document has been completed for the ultimate design of I-680/ SR-4 interchange. It included a technical memorandum regarding the placement of a possible set of direct HOV connectors at some time in the future, so as to ensure that any other improvements made in the meantime do not preclude the later construction of the connection between the HOV lanes on I-680 and SR-4.
- As part of a pavement rehabilitation project, Caltrans is adding an HOV lane from Rudgear Road south to connect with the existing southbound HOV lane that currently starts at Livorna Road. This will reduce the effect of several lane drops that occur between SR-24 and Livorna Road. This one-mile project is expected to start in 2010.
- A PSR is being prepared by Caltrans for the Gap Closure Project, which will add a southbound HOV lane to fill the gap in the existing southbound HOV facility between N. Main Street and Livorna Road. The study found that it may be possible to add an 11-foot HOV lane in the southbound direction by narrowing three existing lanes from 12-feet to 11-feet, narrowing the insider shoulder from 10-feet to 2-feet, and eliminating an existing enforcement area. However, the lane can only be implemented if design exceptions are allowed for sub-standard outside shoulders at pinch points such as those shown in Figure 7 and 8.

  The same study also found that there were additional costs besides the cost of bringing the shoulder pavement to travel lane standards and re-striping. These costs include such factors as relocating a fiber-optic cable buried beneath the inside shoulder (cost: $275K), replacing the 50-inch median barrier with a barrier meeting the new 60-inch standard ($211K for removal and $950K for replacement), traffic management plan for night work ($1.2M), modifying loop detectors, installing ramp meters in accordance with Caltrans' *Ramp Metering Guidelines* even at ramps that were not modified by the project (cost: $110K per

ramp), highway lighting ($170K), drainage improvements ($2.5M), removal of contaminated soil from the section where the roadway is to be widened ($200/sq-meter or $3M/mile), $4.9M in environmental mitigation not counting $5M for soundwalls on piles and $2M for landscaping. These additional costs highlight the need for generous contingencies to be added when forecasting the cost of the regional HOT lane network.

The total cost for the 3.7-mile section is estimated to be $80M, or over $20M/mile. A second alternative was looked at that would bring the widened section up to full standards by replacing many of the structures, including the BART overcrossing. The estimated cost was $150M, or about twice as much as the reduced-standard alternative[4].

- A study[5] was also performed for retro-fitting an HOV lane in the northbound direction. The study found that the physical constraints in the northbound direction were more severe than in the southbound direction (see Figures 9 and 10). Moreover, the 3-lane connector ramp from eastbound SR-24 to northbound I-680 lands on the median side of I-680, which means that an HOV lane coming from the south that had been adjacent to the I-680 median up to that point would suddenly be in middle of the freeway, with three mixed-flow lanes on either side (see Figure 11). It would be physically possible to develop a northbound HOV lane that passes beneath the connector and re-joins the northbound freeway in such a way that it would be to the left of all general-purpose lanes. However, this could only be done by encroaching on the space required by the southbound lanes, and so it would be solving the northbound problem by creating a problem in the southbound direction.

  The study also concluded that taking additional right-of-way or converting a general purpose lane to HOV operations would not solve the problem at the SR-24 landing.

- The possibility of building a northbound HOV flyover was explored but found to be infeasible because it would have to pass over viaducts that are already at

[4] However, this alternative was not considered feasible and so was not studied to the same level of detail.

[5] *I-680 Investment Options Study*, CCTA, 2003

level 3 which would make the flyover both very expensive (approximately $115M) and visually intrusive. Moreover, the connector would do little good unless the HOV lane could be extended to SR-242, which appears to be precluded by other pinch points (see Figures 2 and 3).

- An operational analysis was performed of possibility of converting one general-purpose lane to HOV-only operation. Caltrans concluded that this corridor should not be exempted from its general policy against take-a-lane conversion due to the traffic impacts that would be created.

HOT Lanes Proposal – Mainline

The potential to provide the main line of the HOT facility varies by section along the freeway:

- From the Benicia Martinez Bridge to the junction of SR-242, I-680 has an existing HOV lane in both directions. In the southbound direction of travel, conversion to a HOT lane can be accomplished by adding a 2-foot buffer between the HOV lane and the adjacent general purpose lanes, and providing appropriate signing and tolling equipment. The necessary 2-foot buffer could be created by narrowing two inside lanes from 12-feet to 11-feet. Although there are portions of this section where widening the freeway appears to be feasible (see Figure 12), there are other portions where the cost of doing so would be difficult to justify when re-striping to narrower lanes would be sufficient (see Figure 13).

  The actions taken for this section in the northbound direction would depend on the action taken in the sections immediately upstream, which are discussed below.

- From the SR-242 interchange to the SR-24 interchange, I-680 widens up to seven lanes per direction. For the southbound direction, the Basic Approach to providing a HOT lane is to add the 2-foot buffer to the planned Gap Closure HOV lane by further narrowing the shoulders. The inside shoulder would be narrowed to not less than 2 feet and if necessary the outside shoulder would be narrowed as required to provide the required space.

The most challenging location is where the shoulders on both sides of the southbound direction have been consumed to accommodate piers of the BART overcrossing (see Figure 7). The Gap Closure plan would leave 1.3 feet of clearance on the right side and 3 feet of clearance on the left, with all lanes reduced to 11-foot width except for the outside lane (see Figure 14). Section 3.9 of the Caltrans *HOV Guidelines* suggests eliminating the buffer in such a constrained situation. However this would, in effect, create a new access point that might have the unintended effect of prompting drivers to make weaving movements in a very unsuitable location and would go against the design guidance of providing transition lanes at access points. There are two other alternatives that would provide a potentially safer design:

- This section currently consists of three through lanes plus an acceleration lane extending from the on-ramp from Ygnacio Valley Road. Eliminating the on-ramp would free up space for the addition of the HOT lane and buffer while maintaining the same shoulder width on each side. However, existing users of the ramp may object to its closure.

- Another option would be to create additional space by relocating and replacing the BART pier that currently constrains the outside shoulder of the southbound lanes (shown on the left of Figure 7). It would be replaced with an outrigger structure and relocated west side column that would allow for a widening about 10 feet on the right side. An example of similar column relocation is shown in Figure 15 from San Diego. The outrigger would straddle the southbound mainlanes with columns in the center median and between the mainlanes and the on-ramp to SR-24, shown in Figure 16, taking advantage of the available space and the high vertical clearance available at the site. The outrigger would be constructed under the existing structure to avoid disrupting BART service.

  The advantage of this approach is that it would accommodate the existing through lanes, the existing ramp lane, the proposed HOT lane and buffer, and several feet of shoulder on both sides. However, this

option would be significantly more expensive than closing the upstream on-ramp.

The various options for this section are summarized in Table 1 below:

Freeway Component	Existing	Gap Closure Plan	Close Ramp Option	Outrigger Option
Outside Shoulder	7.3	1.3	10.0	3.0
GP Lane #4	12.0	12.0	-	12.0
GP Lane #3	12.0	11.0	12.0	11.0
GP Lane #2	12.0	11.0	11.0	11.0
GP Lane #1	12.0	11.0	11.0	11.0
Buffer	-	-	2.0	2.0
HOV or HOT Lane	-	11.0	12.0	11.0
Inside Shoulder	5.0	3.0	2.3	3.0
Total Width (feet)	60.3	60.3	60.3	64.0

Table 1: Allocation of Width under Different Options

The Revised Full Featured Approach would require replacement of the BART overcrossing with a structure allows for more horizontal clearance. If this was ruled out due to cost, then this spot location would be treated as described for the Basic Approach.

- In the northbound direction the most feasible solution is that the HOT facility be discontinuous in this section due to the high cost of structure and retaining wall modifications that would be required to create the necessary space. The discontinuity in this section along with a second discontinuity at the Benicia Martinez Bridge raises the question of whether it is worthwhile to have a HOT lane for the relatively short section in between. The alternative would be to keep the conventional HOV lane for the section from Main Street to the Bencia Martinez Bridge. This may have operational advantages in terms of offering continuous access to and from the HOV lane, but at a cost of foregoing the traveler benefits that could be derived from allowing toll-paying single-occupant vehicles from using a HOT lane.

- South of SR-24 the freeway has five general purpose lanes per direction (see Figure 17), dropping to four per direction south of Rudgear Road (see Figure 18). In the southbound direction, the HOV lane planned as part of the Gap Closure Project could be converted to a HOT lane by adding a 2-foot buffer between the HOV lane and the adjacent general purpose lanes, and providing appropriate signing and tolling equipment. The 2-foot buffer could be created by reducing the inside shoulder from 10-foot to 8-foot in width.

  In the northbound direction it would be technically feasible to extend the existing HOV lane from Livorna to a point just south of the Rudgear Road off-ramp by widening the freeway into the hillside (Figure 19). However, this hillside is part of the Sugarloaf Open Space Recreation Area and so there may be opposition to this solution. Some side slopes or low retaining walls may be necessary.

HOT Lanes Proposal – Ingress and Egress Points

The approach taken in this study is that the placement of ingress and egress points should be primarily demand-driven; that is, ingress points should be located at a convenient distance downstream of places where large volumes of traffic enter the freeway system and egress points should be located at a convenient distance upstream of places where large volumes of traffic leave the freeway system. Once the high-demand locations were identified, an analysis was then performed to determine whether an ingress or egress point could fit within the physical constraints of the location. In the event that the point could not be accommodated, a further analysis was performed to determine whether it could be accommodated by shifting the ingress or egress point to a location near the optimal point. Alternate locations for ingress points were sought downstream of the optimal point while alternate sites for egress points were sought upstream, meaning in effect that traffic wishing to enter or leave the HOT lane would have a longer distance in which to weave across the general purpose lanes. If no alternative site could be found then consideration was given to dropping the proposed site with the assumption that potential users of the point would enter or exit the HOT lanes at other points in the corridor.

The assumed designs of the ingress and egress points are shown in Figures 20 and 21. These designs closely resemble the M-5 design found in Caltrans' *HOV Guidelines*[6] as modified for the proposed access points for the I-680 Sunol Express Lane in Alameda and Santa Clara Counties. Caltrans also has specified a required minimum distance between an HOV access point and the nearest freeway ramps (see Figure 22) that were considered when determining the location of potential ingress and egress locations.

Figures 23 through 26 show the volumes of traffic entering and exiting I-680 at various points along the corridor[7]. The observable patterns are summarized below:

- The largest volume of southbound entering traffic occurs at the interchange with SR-242 (see Figure 23). A second large volume of traffic enters at SR-4. The remaining entering volume is spread fairly evenly among the closely-spaced interchanges in Concord, Pleasant Hill, and Walnut Creek.
- The largest southbound exiting volume occurs at the SR-24 interchange (see Figure 24). Significant exiting volumes also occur in Concord, Pleasant Hill, and Walnut Creek.
- The largest volume of northbound entering traffic occurs at the interchange with SR-24 (see Figure 25). The remaining volume is spread fairly evenly among the closely-spaced interchanges in Concord, Pleasant Hill, and Walnut Creek.
- The largest northbound off-ramp volumes occur at the SR-242 interchange (see Figure 26). Significant exiting volumes also occur in Concord, Pleasant Hill, Walnut Creek.
- There is very little traffic on the on- and off-ramps between SR-4 and the bridge.

Based on the pattern of entering and exiting traffic, a total of twelve potential sites for ingress and egress points were identified for this corridor (see Figure 27). Each site was analyzed for engineering feasibility, with a variety of results:

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[6] Source: Caltrans *High-Occupancy Vehicle Guidelines for Planning, Design, and Operations*, August 2003

[7] Source: Caltrans' *2006 Traffic Volumes Report*

- Six sites were dropped because they were in or very near the northbound section of freeway where HOT lanes appear to be infeasible without high cost or serious impacts to the community caused by major structures and/or additional right-of-way needs.
- In two cases the positions of the ingress and egress locations were switched in order to better serve weaving traffic. When positioning access points between interchanges, placing the egress point upstream maximizes the weave distance to the next off-ramp.
- In one case the only way to accommodate both an ingress and an egress point in the same section of freeway was to allow their tapers to overlap, as shown schematically in Figure 26.

Table 2 summarizes the conclusions that were reached for each access point. The revised plan is summarized in Figure 29, and shown in detail in Figures 30 through 32.

Findings Regarding HOT Lane Development in this Corridor

Based on this analysis, the development of HOT lanes in this corridor appears to be feasible in the southbound direction. However, there are serious physical constraints at several pinch points that would require design exceptions.

No technically feasible solution was found that would allow a HOT lane to be implemented in the northbound direction in the immediate vicinity of the SR-24 interchange without high cost or serious impacts to the community caused by either major structures and/or additional right-of-way needs. Therefore it appears that the HOT facility would need to be discontinuous in this section. Since a second discontinuity already occurs on the Benicia Martinez Bridge, which has no HOV lanes or space to add a lane, it might make sense to restart the northbound HOT lane north of the Benicia Martinez Bridge.

The complex and tightly-constrained situation in this corridor may recur in other portions of the regional HOT lane network, such as portions of I-80 near the Oakland-San Francisco Bay Bridge.

Table 2: Summary of Potential Southbound Ingress and Egress Points

Site	Location	Conclusion	Comments
SB-I1	South of SR-4 interchange	Moved	These two switched positions to better meet the Caltrans' minimum required distances to nearby ramps. Both on bridges. Some overlap in tapers. Large building adjacent to freeway.
SB-E1	Just north of Willow Pass Rd	Moved	
SB-I2	At Monument Blvd interchange	Feasible	Includes overcrossing of Monument Blvd
SB-E2	Just north of Main Street	Dropped	Closely-spaced interchanges do not leave enough space to meet minimum weaving distances
SB-I3	Just south of Rudgear Road	Moved	These two switched positions to better meet the Caltrans' minimum required distances to nearby ramps. End of taper for SB-I3 is on Stone Valley Road bridge.
SB-E3	At Livorna Rd interchange	Moved	
NB-I1	Between Rudgear Rd and Livorna Rd	Dropped	At northern terminus of HOT lane
NB-E1	Just north of Broadway Interchange	Dropped	In gap in the HOT lane
NB-I2	Just south of Main Street Interchange	Dropped	In gap in the HOT lane
NB-E2	Between Geary Rd and Oak Park Rd	Dropped	In gap in the HOT lane
NB-I3	Just south of SR-242 interchange	Dropped	In gap in the HOT lane
NB-E3	Just south of SR-4 interchange	Dropped	In gap in the HOT lane

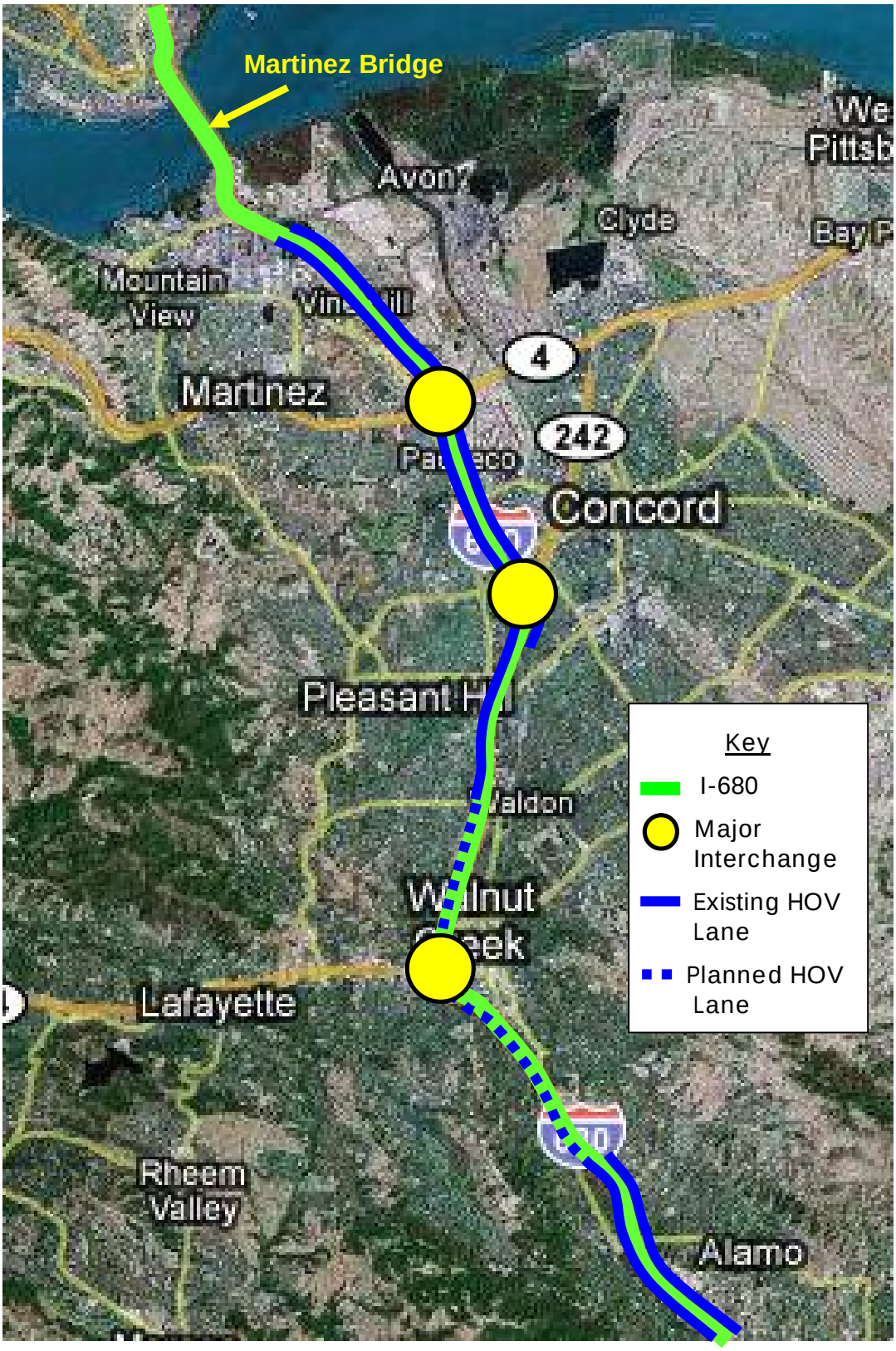

Figure 1: Study Corridor

Figure 2: Ramp Bridge in Pacheco Road Interchange looking Northbound

Figure 3: Railroad Bridge South of Pacheco Road Interchange looking Northbound

Figure 4: I-680/SR-24 Interchange

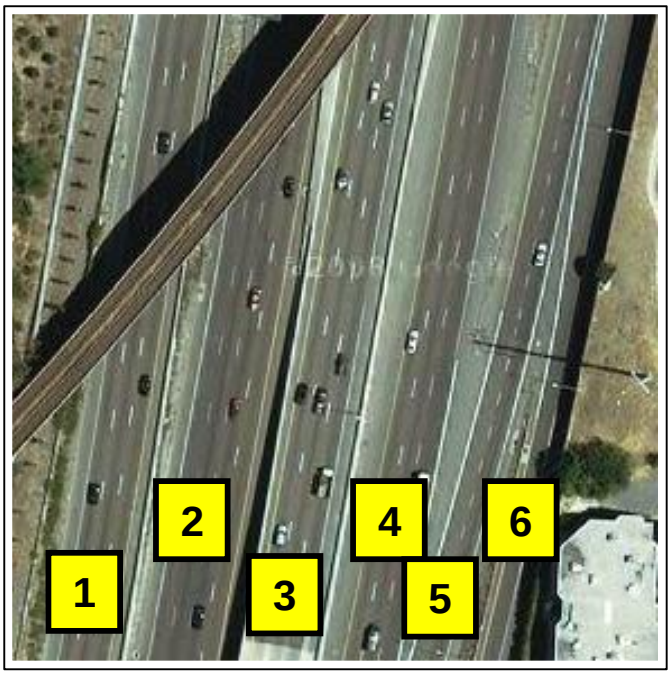

Figure 5: Portions of I-680 offer a complex environment for drivers, such as this section near the BART overcrossing, with six carriageways side-by-side

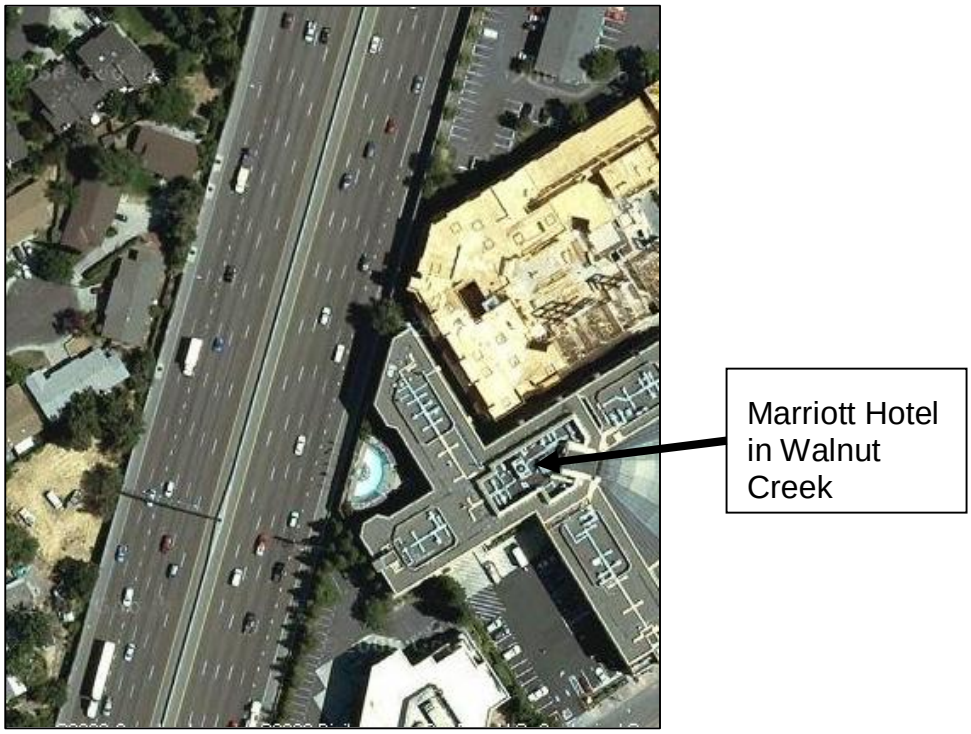

Figure 6: This section is constrained by buildings directly adjacent to the freeway

Figure 7: Pinch Point in Southbound Direction Under BART Tracks

Figure 8: Pinch Point in Southbound Direction Under SR-24 Connector Ramp

Figure 9: A Pinch Point in the Northbound Direction under SR-24 Ramps

Figure 10: A Pinch Point in the Northbound Direction near the BART Tracks

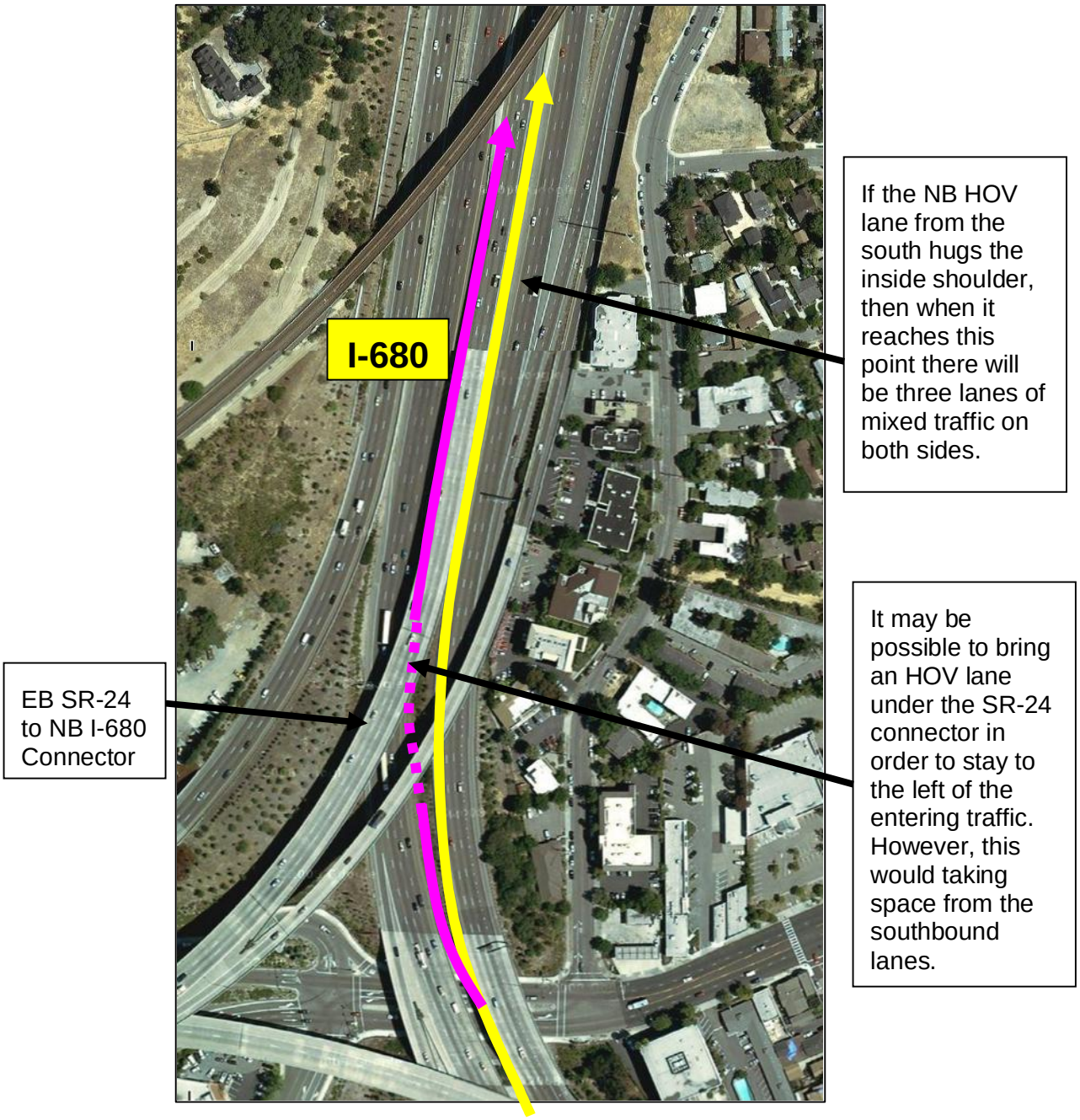

Figure 11: Potential Alignments for a Northbound HOT Lane in Vicinity of the SR-24 Interchange

Figure 12: I-680 South of Pacheco Blvd Interchange and SR-4 Looking Southbound

Figure 13: A Constrained Section over Blum Rd North of SR-4 Looking Southbound

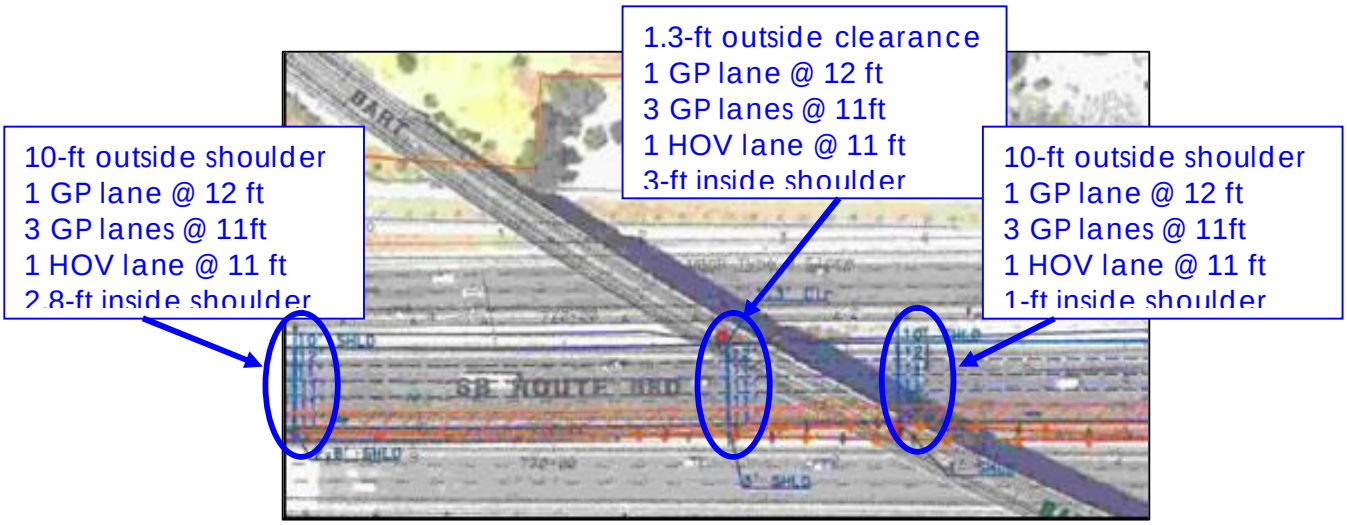

Figure 14: Portion of SB Gap Closure Plan at BART Undercrossing

Figure 15: Outrigger Used to Replace a Median Pier in San Diego

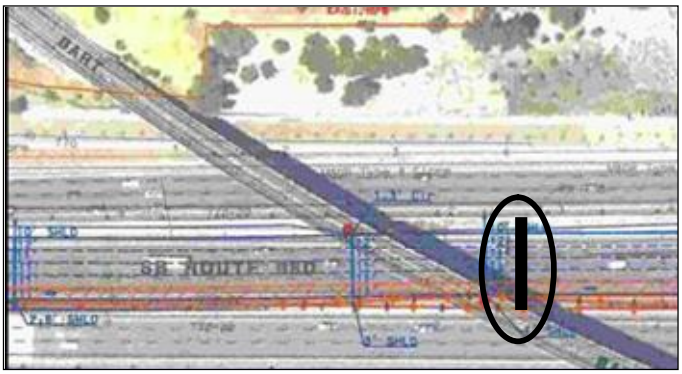

Figure 16: Proposed Location for Outrigger

Figure 17: I-680 Just South of S. Main Street Interchange Looking Northbound

Figure 18: I-680 Just South of Rudgear Road, Looking Southbound

Figure 19: I-680 Just South of Rudgear Road, Looking Northbound

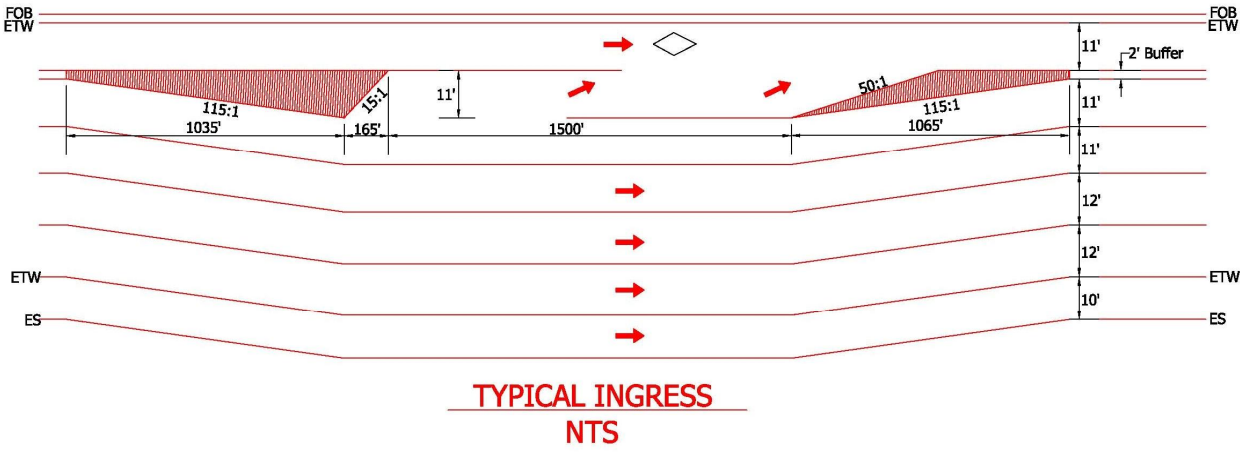

Figure 20: Typical Ingress Point for HOT Lane

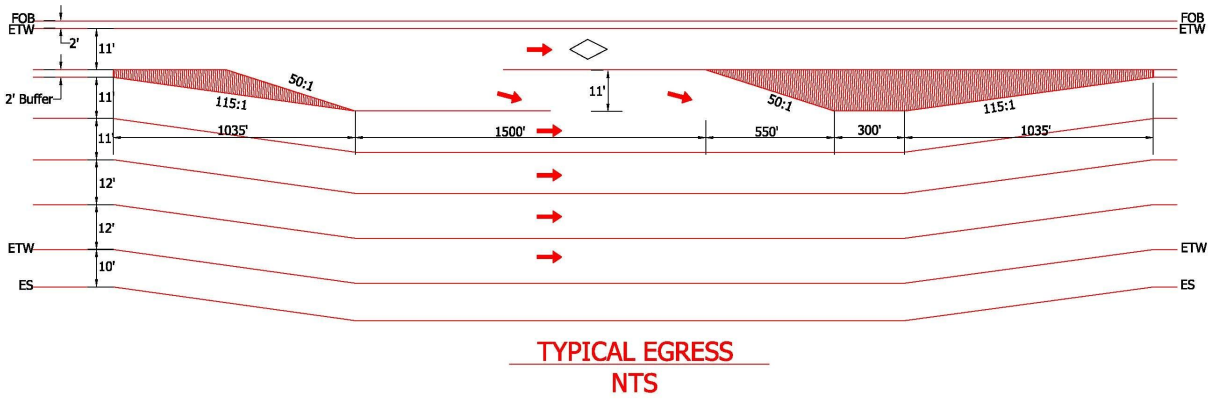

Figure 21: Typical Egress Point for HOT Lane

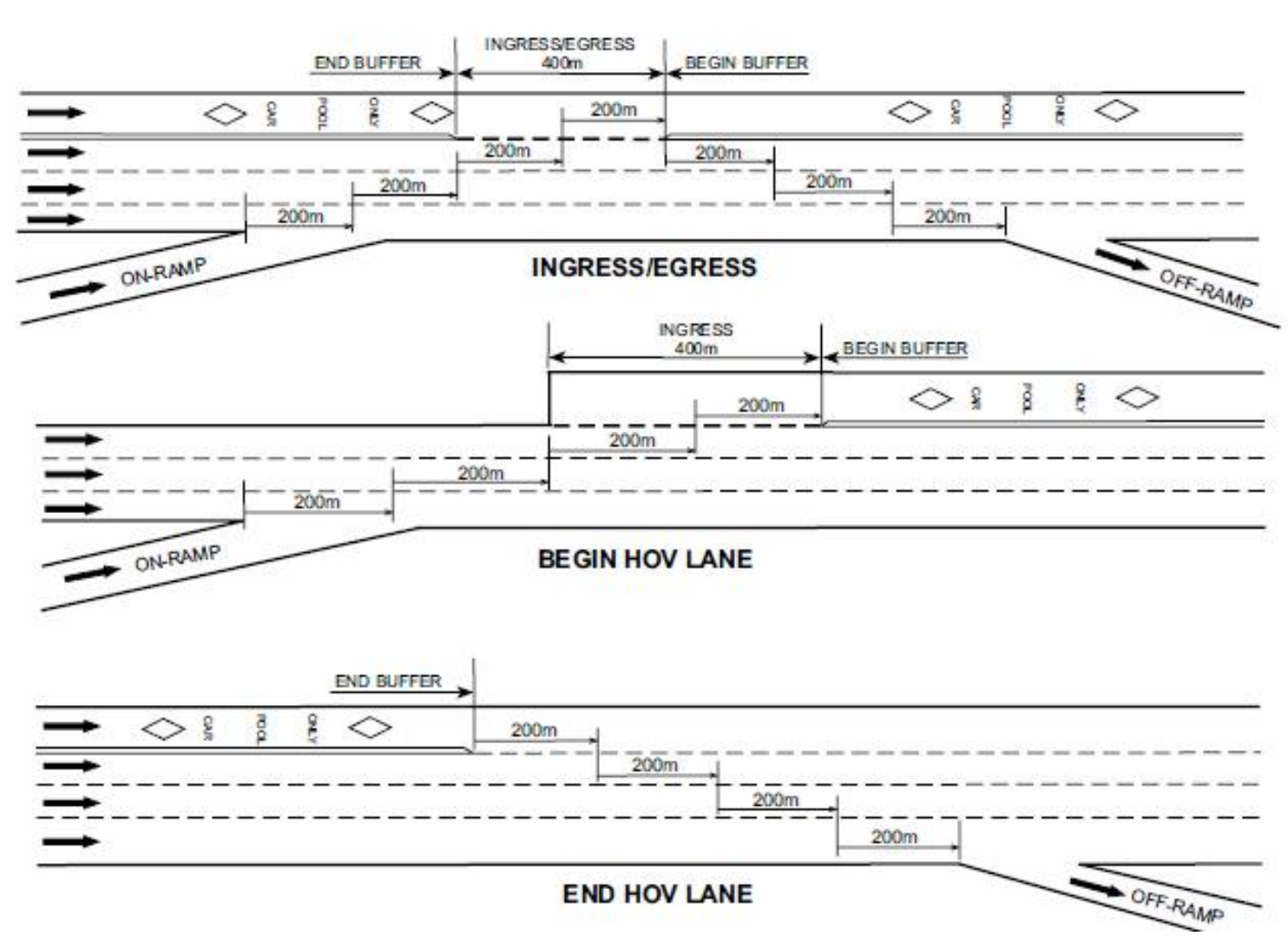

Figure 22: Caltrans Minimum Weave Distance at Buffer-Separated HOV Facilities

Figure 23: Southbound On-Ramp Volumes

Figure 24: Southbound Off-Ramp Volumes

Figure 25: Northbound On-Ramp Volumes

Figure 26: Northbound Off-Ramp Volumes

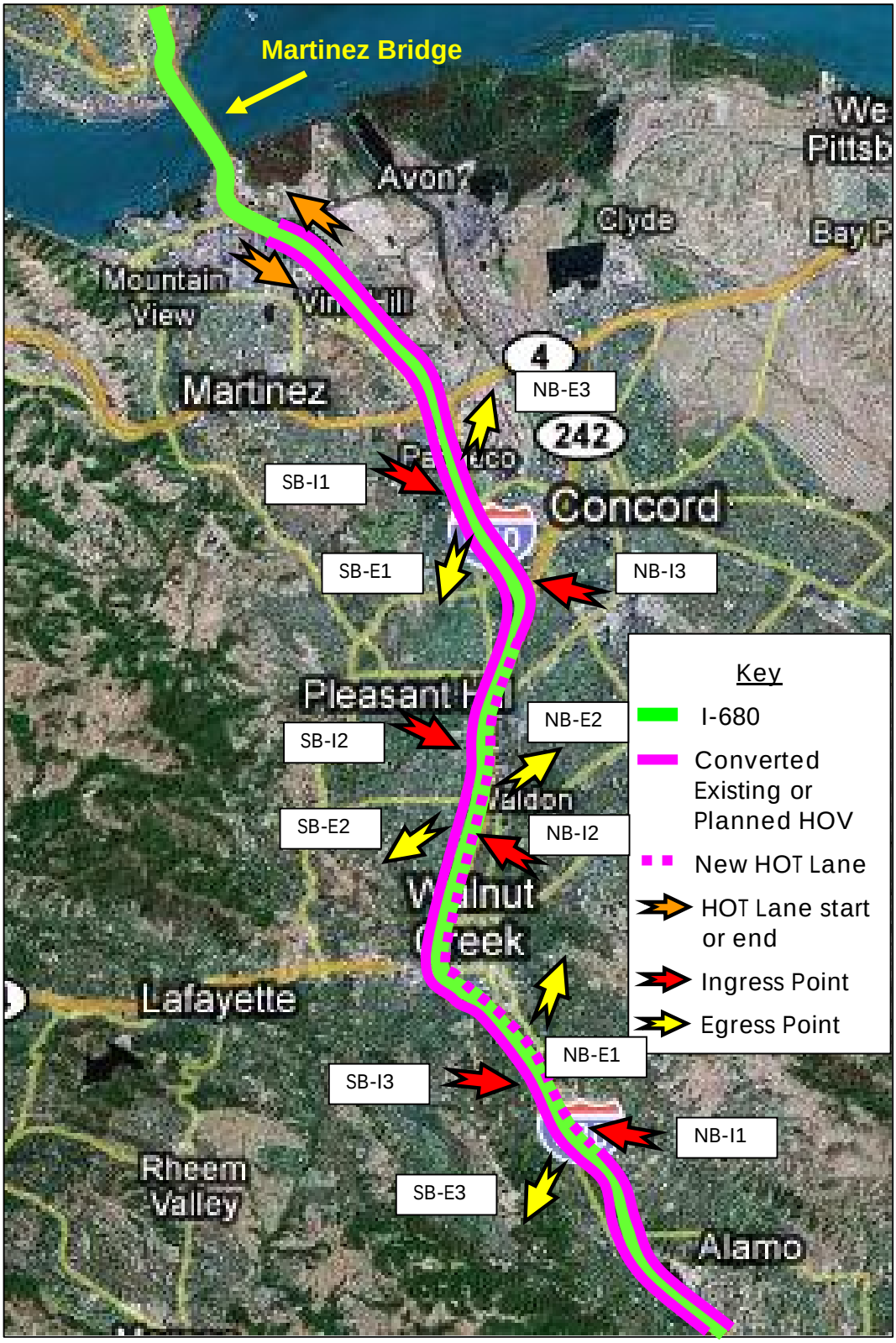

Figure 26: Demand-Driven Ingress and Egress Locations

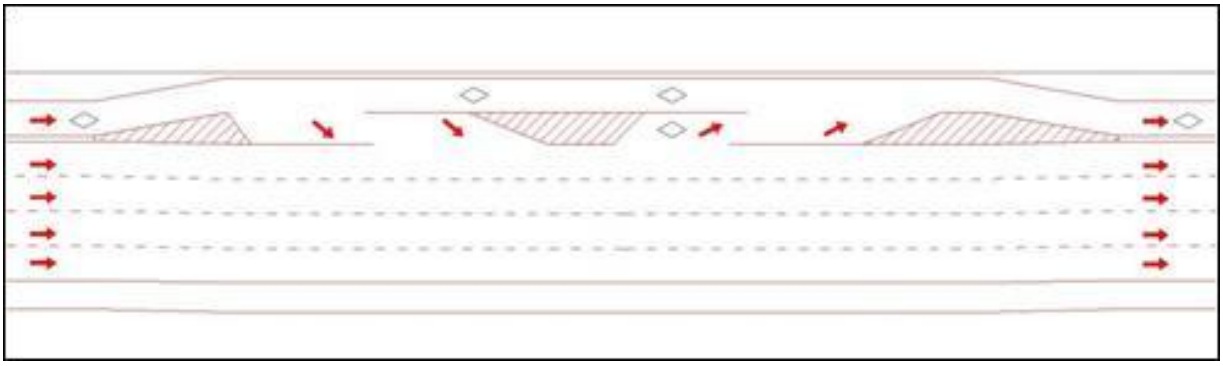

Figure 28: Schematic of Egress and Ingress Points with Overlapping Tapers

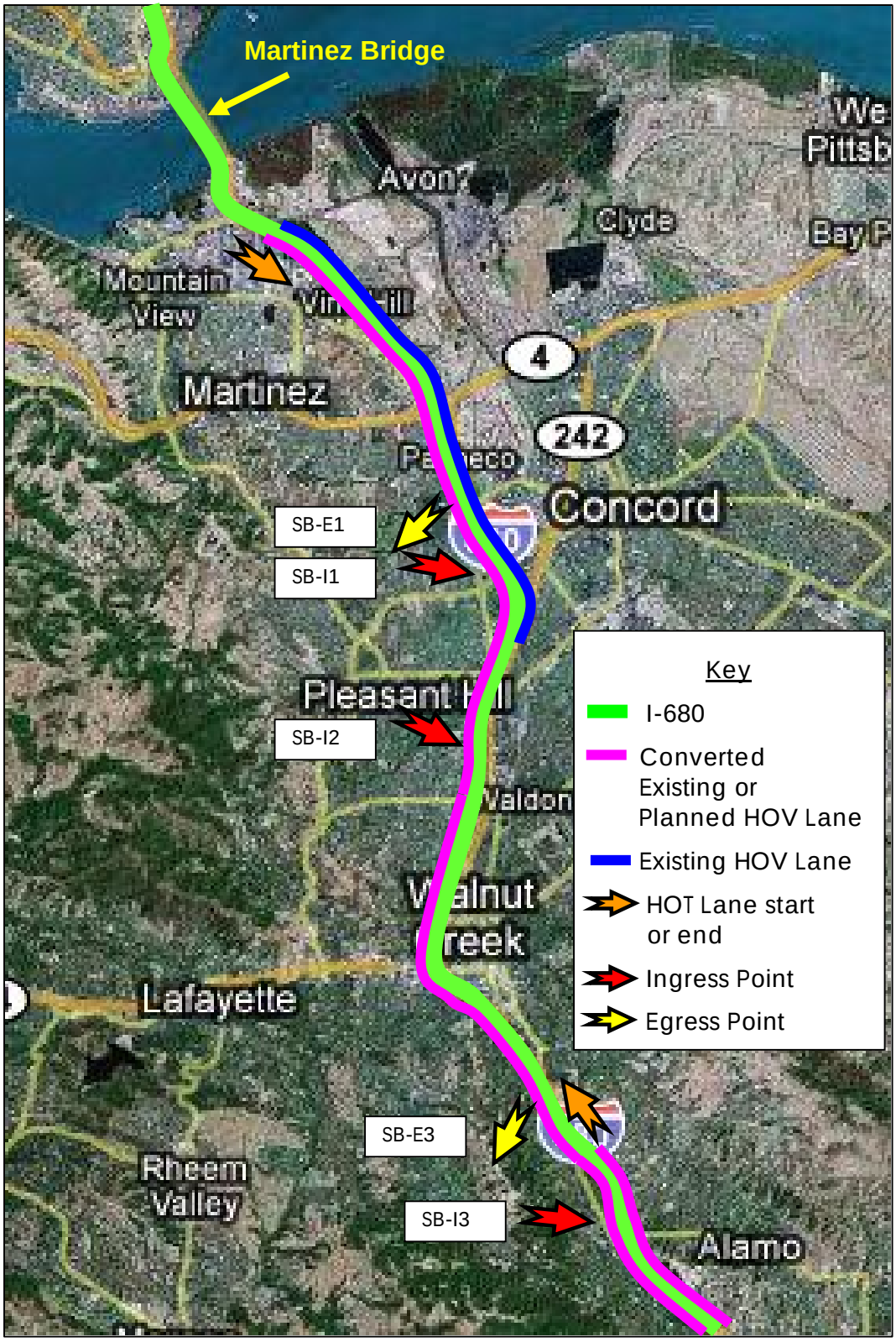

Figure 29: Revised Ingress and Egress Locations